NOTES ON AN ANDORITE-BEARING SILVER ORE FROM NEVADA.

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INTRODUCTION.

A specimen of rich silver ore recently examined in the laboratory of the United States National Museum proved to consist largely of the rare lead-silver sulphantimonite andorite ($2PbS.Ag_2S.3Sb_2S_3$). This mineral has previously been found at Felsobanya in Hungary, and at Oruro, in Bolivia, but has not heretofore been identified from any locality in North America. The ore is described in some detail below. The specimen came to the Museum from the Centennial Exposition (1876) and was catalogued by former Curator F. P. Dewey (Cat. No. 15,908) as from Mr. M. F. Randolph, Keyser Mine, Morey District, Nye County, Nevada.

DESCRIPTION OF THE ORE.

The andorite ore specimen will average perhaps 1,000 ounces of silver a ton, most of which is in the form of andorite or an alteration product of andorite. As judged from a study of this single specimen the earliest mineralization of the vein was a pale pinkish manganiferous carbonate containing a very small amount of finely divided contemporaneous pyrite. The carbonate filled most of the available open space, except some narrow vugs, which were lined with acute rhombohedral crystals of the rhodochrosite. Later movement resulted in extensive brecciation of the carbonate mineralization followed by the introduction of much granular quartz accompanied by silver minerals, which partly replaced the brecciated carbonate and were deposited in the quartz, and later zinc sulphide, which replaced the quartz. Small open cavities in the quartz are lined by drusy quartz crystals upon which rest very rare grains of pyrargyrite and stephanite. One vug contained a crystal of selenite gypsum as the last mineral deposited.

DESCRIPTION OF THE ANDORITE.

The andorite forms prismatic grains which are apparently contemporaneous with the quartz and range from pure andorite to andorite-quartz intergrowths or andorite shells inclosing a large amount of quartz. The prisms, which have ragged edges, reach an extreme length of 1.5 cm. with a width of 4 mm. They lie disseminated in the granular quartz like phenocrysts in a porphyry and show no regularity of arrangement. The associated sphalerite, which is dark brown with well developed cleavage, forms rounded grains up to 1 mm. in diameter disseminated in the quartz between the andorite prisms. These are apparently replacements of the quartz and while grains of sphalerite occasionally have a core of andorite the andorite never incloses sphalerite. The sphalerite shows a purple-gray color and metallic luster on polished surfaces. The andorite has a brilliant metallic luster and light lead-gray color. It is devoid of cleavage and has a conchoidal fracture when unaltered. The hardness is about 2.5 and on unglazed porcelain the mineral yields a soft dull black streak which when rubbed with a glass rod becomes first shining and then decidedly brown. The mineral assumes a yellowish tarnish upon exposure. Material was hand picked for analysis, care being used to avoid, as far as possible, the material showing the alteration described below. The analyzed sample contained some quartz and also a little sphalerite, the latter mineral being recognized as isotropic dark brown grains when the analyzed powder was examined under the microscope. Insoluble quartz deducted, the analysis yielded the following percentages:

Analysis of andorite from Nevada.

Lead (Pb)	23.35
Silver (Ag)	12.09
Iron (Fe)	1.55
Zinc (Zn)	3.56
Antimony (Sb)	37.64
Sulphur (S)	22.63
Total	100.82

Of the above tabulated constituents zinc is certainly foreign and present as sphalerite and it seems most reasonable to consider the iron as also extraneous and associated with the zinc sulphide as an impurity. These metals deducted, the analysis furnishes the following ratios:

Ratios of andorite from Nevada.

Pb	0.1127	11.27	1.13 x 1	1.09 x 1
Ag	.1121	11.21	1.12 x 1	1.08 x 1
Sb	.3131	31.31	1.04 x 3	1.00 x 3
S	.7057	70.57	1.01 x 7	.97 x 7

These ratios indicate closely the andorite formula:

$$PbAgSb_3S_7 \text{ or } 2PbS.Ag_2S.3Sb_2S_3.$$

The results in percentages of the essential constituents are below recalculated to 100 per cent and compared with the theoretical percentages to suit the andorite formula:

	Original.	Recalculated.	Theory.
Lead	23.35	25.06	23.87
Silver	12.09	12.98	12.45
Antimony	37.64	40.41	41.49
Sulphur	20.08	21.55	22.19
Total	93.16	100.00	100.00

This comparison shows that, while the mineral agrees in all essential respects with andorite, it is slightly high in lead sulphide and correspondingly low in silver and antimony. This may be due to incipient alteration along the lines discussed below.

The andorite gives, before the blowpipe, the usual reactions for silver, lead, antimony, and sulphur. In the closed tube it decrepitates slightly and fuses at a moderate temperature but without conspicuous decomposition, yielding faintly perceptible rings of sulphur and antimony oxide, oxysulphide, and sulphide. In the open tube it gives a copious sublimate of antimony oxide. The mineral is soluble in hot concentrated hydrochloric acid.

ALTERATION OF THE ANDORITE.

While andorite was originally the most abundant metallic mineral of the ore, typical unaltered andorite crystals are now rare, the majority of the individuals being more or less affected by a change which is first manifested by a granular appearance and prismatic cleavage or parting. With further alteration a porous core is developed in the andorite mass with a brilliant blue or purple tarnish. In extreme stages of alteration the andorite contains a central cavity filled with finely felted wool-like material or is replaced entirely by stellar aggregates of fine fibers. Partial analyses indicate that crystals in the first stages of the alteration which have been dulled in luster with the development of granular or subfibrous appearance and prismatic parting do not differ greatly in composition from the unaltered andorite. Two partial analyses of materials showing these changes in properties gave the following results:

Analyses of partly altered andorite.

	1.	2.
Lead	25.54	27.86
Silver	13.35	12.12
Antimony	36.38	38.06

The only noteworthy change is a slight increase in the relative amount of lead, which apparently increases gradually as the alteration proceeds. The end product of the alteration is the fine fibrous material which is present in small amount in pure form. One completely altered crystal was carefully analyzed, although there was only 0.0771 grams of the material for analysis. This yielded the following composition:

Analysis of completely altered andorite.

Lead	45.14
Iron	2.72
Zinc	1.56
Silver	7.78
Antimony	23.22
Sulphur (calculated)	19.58
Total	100.00

This analysis yields the following ratios:

Ratios of altered andorite.

Lead	0.2178	0.2904	1.04 x 8
Iron	.0487		
Zinc	.0239		
Silver	.0721	.0721	1.03 x 2
Antimony	.1932	.1932	.93 x 6
Sulphur	.6105	.6105	.97 x 18

Unfortunately, the homogeneity of the small amount of material analyzed was not demonstrable. Assuming that the above analysis represents a homogeneous mineral, the formula yielded by the ratios is:

$$8(Pb,FeZn)S.Ag_2S.3Sb_2S_3.$$

Separating Fe plus Zn from lead, this becomes:

$$6PbS.2(Fe,Zn)S.Ag_2S.3Sb_2S_3, \text{ or}$$
$$Pb_3(Fe,Zn)AgSb_3S_9.$$

Such a formula would fall in the 3:1 division of Foshag and Wherry and in the bournonite group. However, since iron and zinc were rejected as extraneous constituents of the original andorite, it seems reasonable to likewise reject them here, the formula then becoming:

$$6PbS.Ag_2S.3Sb_2S_3 \text{ or } Pb_3AgSb_3S_8.$$

This formula falls in the 7:3 division, diaphorite group of Wherry and Foshag. While it is probable that a new mineral is here represented, the evidence does not justify the assigning of a new name. A comparison of the last given formula with that of the unaltered andorite brings out the fact that in the process of alteration the ratio of silver to antimony has not changed, while the relative amount of lead has greatly increased. The fact that the alteration has resulted in a great decrease in volume shows that the alteration has been by the removal of silver and antimony rather than by the addition of lead. There is nothing to indicate that this change is the result of surficial weathering or any attendant process. Apparently all of the constituents of this ore are primary and the ore has not been affected by secondary downward sulphide enrichment. It would seem that the andorite, stable under the conditions under which it was formed, became unstable under conditions obtaining later in the history of the vein and broke down, a part of the silver and antimony being removed as sulphides. The loss of silver and antimonial sulphides has been in the same ratio to each other in which they are present in the original mineral, namely, $Ag_2S.3Sb_2S_3$. No simple silver sulphantimonite of these ratios is known.

THE GANGUE CARBONATE.

The carbonate, which forms the earliest mineral of the ore, is pale-pinkish buff (Ridgway) in color and is finely granular, except where it lined open cavities, where it formed crusts of small crystals. The material is brecciated, and some fragments which are isolated in the quartz are largely replaced by finely-divided metallic sulphides. These are too small for their identity to be definitely determined without microscopic study of polished surfaces in reflected light, but it is probable that the grains are mostly andorite and sphalerite. Small fragments of the carbonate were selected free from admixed minerals and analyzed with the following results:

Analysis of rhodochrosite from Nevada.

MnO	49.49
FeO	7.68
CaO	3.13
MgO	.93
CO_2 (calculated)	38.87
Total	100.10

Stated as carbonates of the respective bases this analysis gives:

$MnCO_3$	80.15
$FeCO_3$	12.39
$CaCO_3$	5.59
$MgCO_3$	1.97
Total	100.10

This is, as is to be expected, a relatively pure rhodochrosite. Such highly manganiferous carbonates are very frequent as gangue minerals in hydrothermal silver veins. The significance of this association will be further discussed in a paper which is in preparation.